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Chromosome Numbers of Ten Species of Ferns from Guam, S. Mariana Isls.

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Chromosome numbers are reported for 10 species of ferns from Guam. The report includes the first cytological records for *Lygodium auriculatum* ($2n = c.\ 56, 2x$) and *Pteris spinescens* ($2n = 58, 2x$). The cytotypes of the pteridophytes examined generally showed the same ploidy level as those of neighboring regions. *Phymatodes scolopendria* is a tetraploid with $2n = 144$, the same as south Indian and Taiwanese populations, although diploids with $n = 36$ are widely distributed from Africa to southern China. The cytogeography of the six species complex is noted.

Key words: chromosome number, cytogeography, cytotype, fern, Guam

Guam is the southernmost island of the Mariana Islands in the western Pacific Ocean, about 2000 km east of the Philippines. Guam is about 45 km long and 6-13 km wide. Stone (1970) enumerated 54 species (52 indigenous, 2 introduced) of ferns and four species of fern allies in his "Flora of Guam." His enumeration is based on Wagner & Grether's (1948) comprehensive account in which 10 families, 36 genera, and 57 species of pteridophytes were recorded. About one sixth of the pteridophytes of Guam are pantropical, while most of the rest are distributed in various ranges in the Old World tropics. A few others are confined to Guam or Micronesia (and also Polynesia). Compared to seed plants, of which 58% are introduced, only a few species of pteridophytes are introduced and most of species from Guam are indigenous (Wagner & Grether 1948, Stone 1970).

To our knowledge, no cytological studies have so far been conducted on the pteridophytes from Guam. Cytogeographical data are useful for helping us to understand the biogeography of the pteridophytes from Guam, since most of the species are widely distributed in the Old World tropics or are pantropical. This paper reports the somatic chromosome numbers of 10 species of ferns from Guam.

Materials and Methods

In December, 1998, one of us, Narumi Nakato, collected fixed materials of pteridophytes on Guam for chromosomal studies. A list of species collected, collecting localities, voucher specimens, and somatic chromosome numbers are given in Table 1. The nomenclature follows Stone (1970). For chromosome observations, root tips were immersed in the field in 0.002 M 8-hydroxyquinoline solution. The methods for the subsequent treatments were the same as

TABLE 1. Somatic chromosome numbers in 10 species of ferns from Guam.

Family / Species1)	Locality	Voucher	Chromosome no. (Ploidy level)	Figure
Schizaeaceae				
Lygodium auriculatum (Willd.) Alston	Mt. Santa Rosa	G-12	$2n = c.56^{2)}$ $(2x)$	1 & 11
Pteridaceae				
Adiantum capillus-veneris L.	Agat	G-3	$2n = 60$ $(2x)$	2 & 12
Pteris spinescens C. Presl	Talofofo	G-17	$2n = 58^{2)}$ $(2x)$	3 & 13
Pteris vittata L.	Agat	G-2 & 4	$2n = 116$ $(4x)$	4 & 14
Aspidiaceae				
Thelypteris dentata (Forrsk.) E. St. John	Talofofo	G-15	$2n = 144$ $(4x)$	5 & 15
Thelypteris parasitica (L.) Fosberg	Talofofo	G-16	$2n = 144$ $(4x)$	6 & 16
Thelypteris unita (L.) C. V. Morton	Talofofo	G-14	$2n = 72$ $(2x)$	7 & 17
Tectaria crenata Cav.	Yigo	G-13	$2n = 80$ $(2x)$	8 & 18
Polypodiaceae				
Microsorum punctatum (L.) Copel.	Mt. Santa Rosa	G-11	$2n = 72$ $(2x)$	9 & 19
Phymatodes scolopendria (Burm.) Ching	Mt. Santa Rosa	G-10	$2n = 144$ $(4x)$	10 & 20

1) Family and species names follow Stone (1970).
2) New report for species.

described in Kato & Nakato (1999). Voucher specimens are deposited in the herbarium of the University of Tokyo (TI).

Results and Discussion

Counts of somatic chromosomes of the species examined are shown in Table 1. Cytogeographic data for six of the 10 species, including cytotypes of the same species from other regions, are summarized in Table 2.

1. *Lygodium auriculatum* (Willd.) Alston (Figs. 1 and 11)

This species was treated as *L. semihastatum* (Cav.) Desv. by Wagner & Grether (1948). It occurs in the Mariana Islands and the Philippines. A plant from Mt. Santa Rosa showed $2n = c.\ 56$, which is the first report for this species. Because three basic chromosome numbers, $x = 28$, 29 and 30, have been recorded for the genus (Roy & Manton 1965), *L. auriculatum* may be a diploid based on $x = 28$.

2. *Adiantum capillus-veneris* L. (Figs. 2 and 12)

This species is widely distributed in tropical to warm temperate regions worldwide. Although Wagner & Grether (1948) and Stone (1970) did not record *A. capillus-veneris* from Guam, it occurs on lightly shaded banks at Agat. This species seems to have become naturalized recently in Guam. One individual was a diploid with $2n = 60$ ($x = 30$), the same cytotype as reported from various regions throughout the world, such as Ireland, Italy, Spain (Manton 1950), Portugal (Queirós & Nogueira 1989), Madeira (Manton *et al.* 1986), Sri Lanka (Manton & Sledge 1954), northern, central, southern and western India (Vasudeva & Bir 1982, Khullar *et al.* 1988), the eastern and western Himalaya (Mehra & Verma 1960), Bhutan (Shinha *et al.* 1986), Shanghai and Yunnan, China (Chiu 1981, Kato *et al.* 1992), Taiwan (Chen 1969, Tsai & Shieh 1983) and Japan (Takamiya 1996). In addition, other cytotypes have been recorded; a hyper-diploid with $n = 31$ was reported from Kashmir Himalaya (Munshi 1994), a tetraploid of $n = 60$ from Sikkim, India (Singh & Roy 1988), Tanganyika, Africa (Manton 1959) and Florida (Wagner 1963), and an apogamous triploid from Sikkim, India (Singh & Roy 1988).

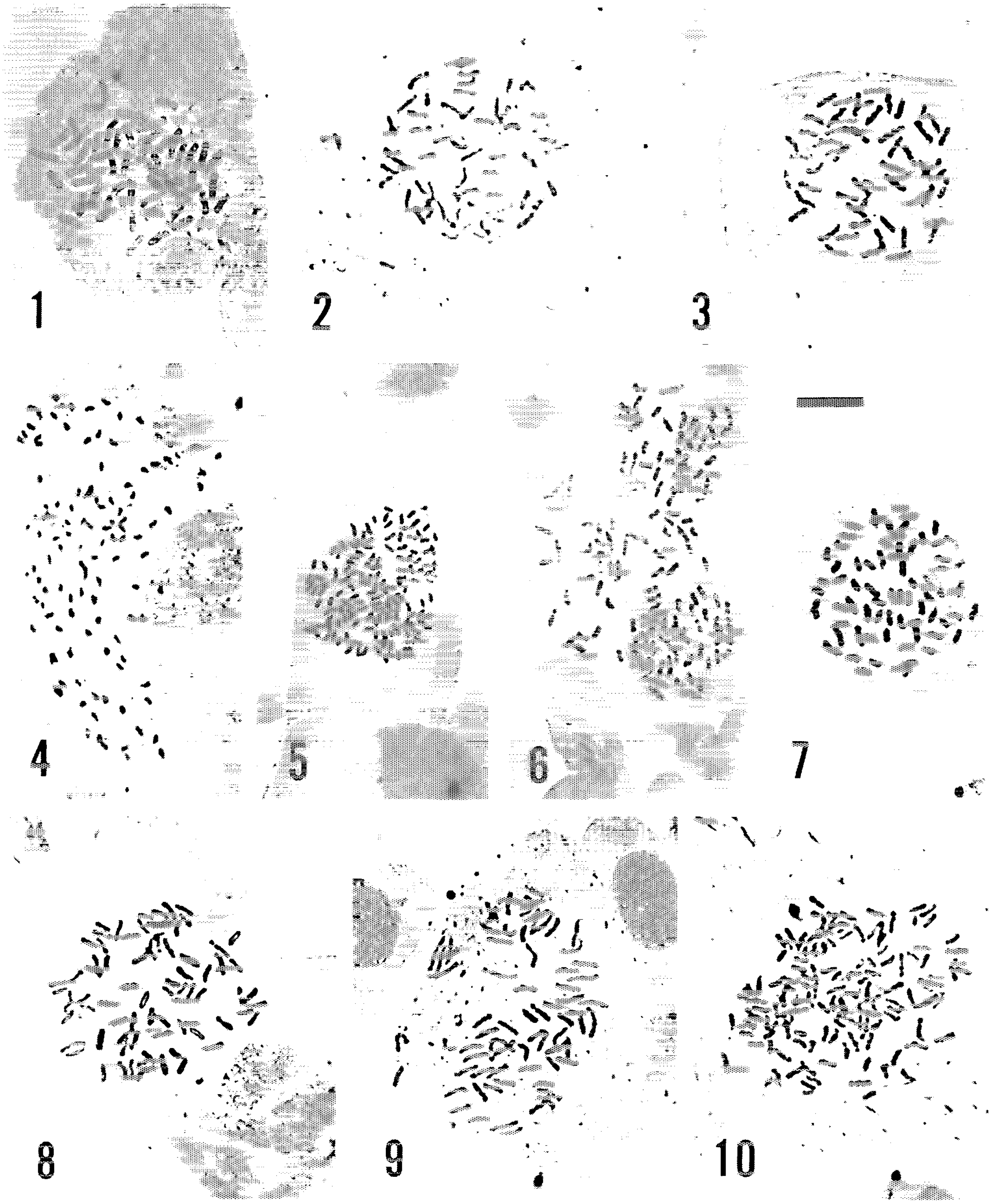
3. *Pteris spinescens* C. Presl (Figs. 3 and 13)
This species is endemic to Micronesia (Stone 1970). Material obtained from the forest floor at Talofofo was found to be diploid with $2n = 58$ ($x = 29$). This is the first report for this species. Wagner & Grether (1948) noted that *P. spinescens* is part of a pantropical aggregate of closely related forms, including *P. quadriaurita* Retz. sensu lato, which was reported to include various cytotypes such as sexual and apogamous diploids, apogamous triploids, sexual and apogamous tetraploids, and sterile pentaploids (Schifferdecker 1957, Walker 1962, Irdayaraj *et al.* 1993).

4. *Pteris vittata* L. (Figs. 4 and 14)
This species is widely distributed in tropical to warm temperate areas in the Old World. According to Stone (1970), it was introduced to Guam probably after World War II, since Wagner & Grether (1948) did not record it. Two plants collected from Agat were tetraploid with $2n = 116$ based on $x = 29$. In this species, sexual diploid, tetraploid and hexaploid cytotypes based on x=29, and several sterile hybrid cytotypes were recorded. Among the cytotypes, the tetraploid cytotype, $2n = 116$, the same as the Guam population, is the most widespread. It is reported from Ghana, Cameroons and Zululand, Africa (Manton 1959, Walker 1962), Sri Lanka (Manton & Sledge 1954), northern, western and southern India (Mahabale & Kamble 1981, Khare & Kaur 1983, Irdayaraj & Manickam 1987), the western Himalaya (Verma & Khullar 1965), Nepal (Walker 1962, Roy *et al.* 1971), Guangzhou, Guangdong, Yunnan and Hainan, China (Wang 1989, Kato & Nakato 1999), the Philippines, New Guinea (Walker 1962), New Caledonia (Fabbri 1963), Taiwan (Mitui 1968, Tsai & Shieh 1983), Japan (Takamiya 1996), and Florida (Wagner 1963).

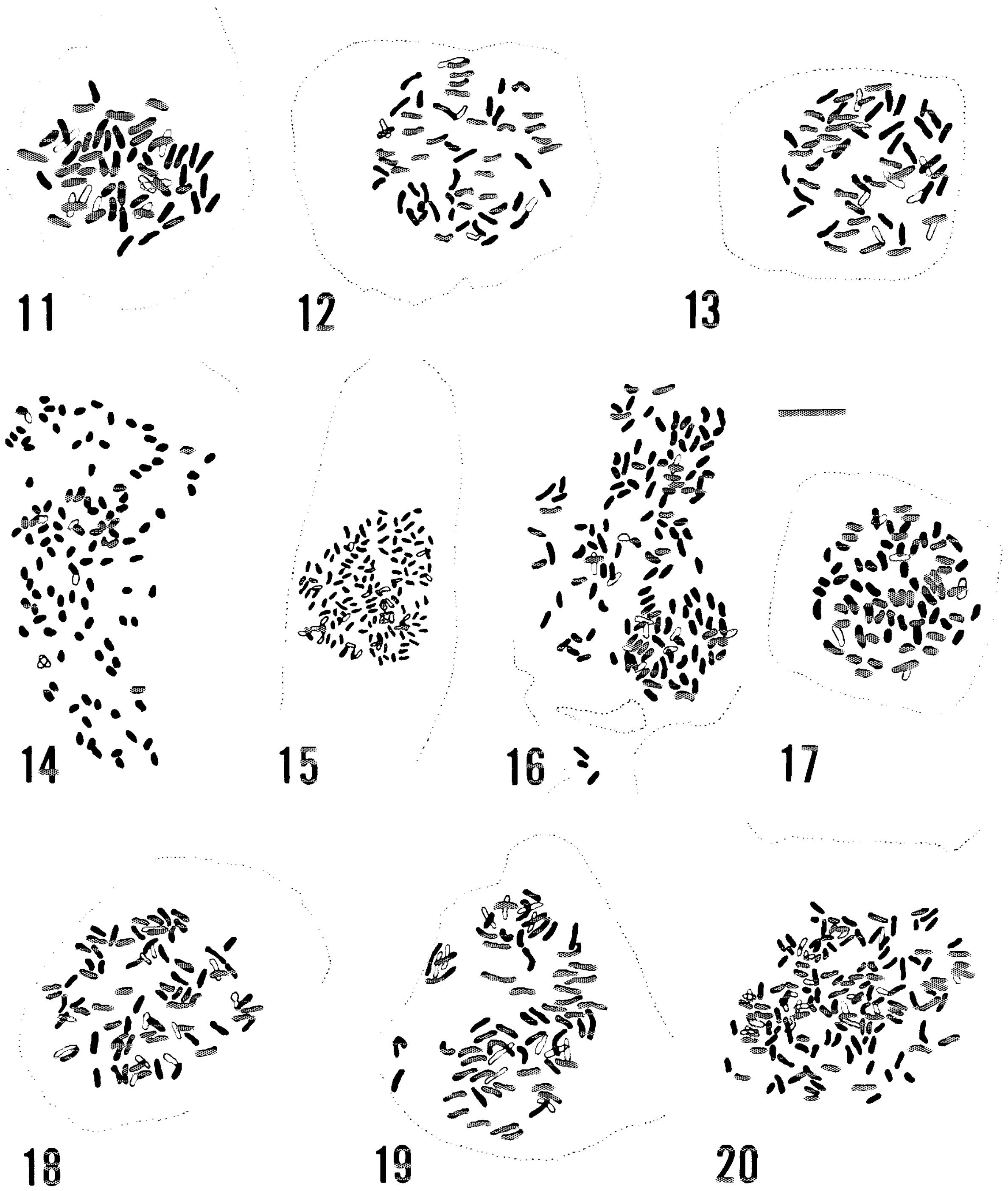
A diploid cytotype is narrowly distributed in Sichuan, Yunnan, Guizhou, Hubei and Hunan, China (Wang 1989), and from southern India (Ammal & Bhavanandan 1991) to the western Himalaya under the name of forma *brebipinna* (Mehra 1961). A rare hexaploid is known only from southern India (Abraham *et al.* 1962, Ghatak 1977) and Sicily, Italy (Brullo *et al.* 1982). Polyploidization apparently played an important role in the spread of this species beyond the narrow distribution range of the diploid to the wider range surrounding it, as mentioned by Wang (1989).

In addition to the sexual reproductive cytotypes mentioned above, an apogamous cytotype, a triploid with $2n = 87$, was reported from Taiwan (Chang *et al.* 1992), and sterile hybrid cytotypes, triploid and pentaploid, were recorded from northern India (Khare & Kaur 1983), and triploids and tetraploids were reported from Yunnan and Guangzhou, China (Wang 1989).

5. *Thelypteris dentata* (Forssk.) E. St. John (Figs. 5 and 15)
This species is primarily distributed in the paleotropics and is now naturalized in tropical America. A plant from Talofofo was found to be a tetraploid with $2n = 144$ ($x = 36$), the same as previous reports from Madeira (Manton & Sledge 1954), Ghana (Manton 1959, Quansah & Edwards 1985), Singapore (under the name of *Cyclosorus subpubescens*, Manton 1954; cf. Panigrahi & Manton 1958), central and southern India (Vasudeva & Bir 1982, Irdayaraj *et al.* 1993), the eastern and western Himalaya (Mehra 1961, Khullar *et al.* 1988), New Guinea (Holttum & Roy 1965), Taiwan (Tsai & Shieh



FIGS. 1-10. Somatic chromosomes. 1, *Lygodium auriculatum*, $2n = c.\ 56$. 2, *Adiantum capillus-veneris*, $2n = 60$. 3, *Pteris spinescens*, $2n = 58$. 4, *Pteris vittata*, $2n = 116$. 5, *Thelypteris dentata*, $2n = 144$. 6, *Thelypteris parasitica*, $2n = 144$. 7, *Thelypteris unita*, $2n = 72$. 8, *Tectaria crenata*, $2n = 80$. 9, *Microsorum punctatum*, $2n = 72$. 10, *Phymatodes scolopendria*, $2n = 144$. Scale bar = 10 μm for all figures.



FIGS. 11-20. Explanatory drawings of Figs. 1-10.
11, *Lygodium auriculatum*, $2n$ = c. 56. 12, *Adiantum capillus-veneris*, $2n$ = 60. 13, *Pteris spinescens*, $2n$ = 58. 14, *Pteris vittata*, $2n$ = 116. 15, *Thelypteris dentata*, $2n$ = 144. 16, *Thelypteris parasitica*, $2n$ = 144. 17, *Thelypteris unita*, $2n$ = 72. 18, *Tectaria crenata*, $2n$ = 80. 19, *Microsorum punctatum*, $2n$ = 72. 20, *Phymatodes scolopendria*, $2n$ = 144. Scale bar = 10 μm for all figures.

1983), Guangdong, China (Weng 1985), Dominica (Smith 1971), Jamaica, Trinidad (Walker 1985), and Paraguay (Smith & Foster 1984). A diploid with n = 36 was reported from northeastern India (Ghatak 1961).

TABLE 2. Summary of variation in cytogeography for six species of ferns on Guam. For data sources, see text.

Species / Locality	Madeira	Europe	Africa	Sri Lanka	India[1]	Malesia	China
Adiantum capillus-veneris	2x	2x	4x	2x	2x, 3x[2], 4x	-[3]	2x
Pteris vittata		6x	4x	4x	2x, 3x, 4x, 5x, 6x	4x	2x,3x,4x
Thelypteris dentata	4x		4x	-	2x,4x	4x	4x
Thelypteris parasitica				4x	2x,4x	4x	2x
Microsorum punctatum			2x	-	2x,4x	-	2x
Phymatodes scolopendria			2x	2x	2x,4x	-	2x

[1] Including the Himalaya.
[2] Apogamous cytotype.
[3] No chromosomal data available for region.

6. *Thelypteris parasitica* (L.) Fosberg (Figs. 6 and 16)

This species is distributed from southeast Asia to the Pacific islands. A plant from Talofofo was found to be a tetraploid with $2n = 144$ ($x = 36$). The species was reported to include two cytotypes in Asia, diploids and tetraploids, based on $x = 36$. The tetraploid has a wider range than the diploid. The tetraploid was recorded from Sri Lanka (Manton & Sledge 1954), Malaysia (Manton 1954), western, central and southern India, and the western Himalaya (Vasudeva & Bir 1982, Irdayaraj *et al.* 1995), Taiwan (Tsai & Shieh 1986) and Japan (Takamiya 1996). The diploid cytotype was recorded from southern India (Irdayaraj *et al.* 1995), Nepal (Roy *et al.* 1971), Taiwan (Tsai & Shieh 1986), and Fujian, China (Weng 1990).

7. *Thelypteris unita* (L.) C. V. Morton (Figs. 7 and 17)

This species is distributed in eastern tropical Africa, and from Asia to Australia and the Pacific Islands. Material from Talofofo was found to be diploid with $2n = 72$ ($x = 36$). Diploid populations were also recorded from Sri Lanka (Manton & Sledge 1954) and southern India (Bhavanandan 1981, Irdayaraj & Manickam 1987).

8. *Tectaria crenata* Cav. (Figs. 8 and 18)

This species is distributed in Malesia and the Pacific islands. A plant from Yigo was found to have $2n = 80$, a diploid based on $x = 40$. A diploid with $n = 40$ was also recorded from Malaysia (Manton 1954).

9. *Microsorum punctatum* (L.) Copel. (Figs. 9 and 19)

This species is distributed in the paleotropics from west Africa through Asia to the Pacific islands. We found a plant from Mt. Santa Rosa to be diploid with $2n = 72$ based on $x = 36$. Diploids were recorded from Ghana (Manton 1959), eastern, western, central and southern India (Bir & Trikha 1978, Mahabale & Kamble 1981), the eastern Himalaya (Singh & Roy 1988), Taiwan (Tsai & Shieh 1983) and, Hainan, China (Kato & Nakato 1999). A tetraploid cytotype, with $n = 72$, was reported from southern India (Abraham *et al.* 1962, Irdayaraj & Manickam 1987).

10. *Phymatodes scolopendria* (Burm.) Ching (Figs. 10 and 20)

This species is widely distributed from tropical Africa, to Asia, Polynesia and Australia. Material from Mt. Santa Rosa was a tetraploid with $2n = 144$ ($x = 36$). The species was reported to be predominantly diploid with $n = 36$

*TABLE 2. (Continued)

Taiwan	Guam	Japan	America	Other region
$2x$	$2x$	$2x$	$4x$	$2x$ (Bhutan)
$3x^{2)}$, $4x$	$4x$	$4x$	$4x$	$4x$ (Nepal, New Caledonia)
$4x$	$4x$	-	$4x$	
$2x$, $4x$	$4x$	$4x$		$2x$ (Nepal)
$2x$	$2x$			
$4x$	$4x$	$2x$		

and/or $2n = 72$ from Ghana (Manton 1959), Sri Lanka (Manton & Sledge 1954), eastern, western, central and southern India (Pal 1961, Abraham *et al.* 1962, Roy *et al.* 1969, Mahabale & Kamble 1981), Hainan, China (Kato & Nakato 1999), and Japan (Takamiya 1996). Tetraploids with $n = 72$ were recorded from southern India (Ghatak 1977) and Taiwan (Tsai & Shieh 1983).

Mahabale & Kamble (1981) reported $2n = 36$ in a plant from western India and concluded that it was a diploid apomict. However, because a diploid apomict with $x = 36$ should be $n = 72$ and $2n = 72$, their conclusion is misleading. Instead, we suspect the individual to be a monohaploid or a paleodiploid in this species, in which the chromosome numbers of $n = 36$ or $2n = 72$ are regarded usually as diploid. Further investigations are needed for understanding such cytological nature.

The pteridophytes of Guam, like those of other tropical oceanic islands, are predominantly pantropical, widely distributed species, since they are usually immigrants from nearby to distant continents and islands. It is likely that the cytotypes that occur on Guam are usually the same as in the same species from neighboring regions. Most of the species we examined exhibit this cytogeographical pattern.

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References

Abraham, A., C. A. Ninan & P .M. Mathew. 1962. Studies on the cytology and phylogeny of the pteridophytes VII. Observations on one hundred species of South Indian ferns. J. Ind. Bot. Soc. 41: 339-421.

Ammal, L. S. & K. V. Bhavanandan. 1991. Cytological studies on some members of Pteridaceae (sensu Copeland) from south India. Indian Fern J. 8: 87-92.

Bhavanandan, K. V. 1981. Studies on the cytology of South Indian Aspidiaceae. Cytologia 46: 195-207.

Bir, S. S. & C. K. Trikha. 1978. Cytological evolution of polyploid ferns with particular reference to the Himalayan forms. *In* Nair P. K. K. (ed.) Glimpses in Plant Research, Vol. IV, pp. 98-130. Viskas Publishing House, New Delhi.

Brullo, S., W. De Leonardis & P. Pavone. 1982. Chromosome numbers of some Sicilian ferns 1. Webbia 35: 275-281.

Chang, Y.-J., W.-C. Shieh & J.-L. Tsai. 1992. Studies on the karyotypes of the fern genus *Pteris* in Taiwan. *In* Tsai, J.-L. & W.-C. Shieh. (eds.) Proc. Second Seminar on Asian Pteridology, Taiwan, pp. 93-109. Nat. Chung Hsing Univ. and Nat. Sci. Couns.

Chen, T.-F. 1969. Chromosome studies on Formosan ferns. Quart. J. Chin. Forest 2: 85-89.

Chiu, P.-S. 1981. Observations on the chromosome numbers of Chinese ferns. Acta Phytotax. Sin. 19: 451-455.

Fabbri, F. 1963. Primo supplemento alle tavole chromosomiche delle Pteridophyta di Alberto Chiarugi. Caryologia 16: 237-335.

Ghatak, J. 1961. Some meiotic counts on the ferns from Khasia-Jaintia Hills. Proc. 48th Indian Sci. Congr. Session Roorke Part III. p. 270.

——. 1977. Biosystematic survey of pteridophytes from Shevaroy Hills, south India. Nucleus 20: 105-108.

Holttum, R. E. & S. K. Roy. 1965. Cytological observations on ferns from New Guinea with descriptions of new species. Blumea 13: 129-139.

Irdayaraj, V. & V. S. Manickam. 1987. SOCGI plant chromosome number reports IV. J. Cytol. Genet. 22: 156-161.

——, S. S. Bir & V. S. Manickam. 1993. Cytology of ferns from the Nilgiris, South India. Fern Gaz. 14: 161-170.

——, V., S. D. Rajkumar & V.S. Manickam. 1995. Studies on intraspecific variation in south Indian ferns: Rediscovery of the rare diploid cytotype of *Christella parasitica* (Thelypteridaceae: Pteridophyta). Fern Gaz. 15: 41-50.

Kato, M. & N. Nakato. 1999. A cytotaxonomic study of Hainan (S. China) pteridophytes with notes on polyploidy and apogamy of Chinese species. *In* Zhang, X.-C. & K.-H. Shing. (eds.) Ching Memorial Volume, pp. 1-19. China Forestry Publishing House, Beijing.

——, ——, X. Cheng & K. Iwatsuki. 1992. Cytotaxonomic study of ferns of Yunnan, Southwestern China. Bot. Mag. Tokyo 105: 105-124.

Khare, P. B. & S. Kaur. 1983. Intraspecific polyploidy in *Pteris vittata* Linn. Cytologia 48: 21-25.

Khullar, S. P., S. Sharma & S. C. Verma. 1988. SOCGI plant chromosome number reports VI. J. Cytol. Geneti. 23: 38-52.

Mahabale, T. S. & S. Y. Kamble. 1981. Cytology of ferns and other pteridophytes of western India. Proc. Indian Natn. Sci. Acad. B. 47: 260- 278.

Manton, I. 1950. Problems of Cytology and Evolution in the Pteridophyta. Cambridge Univ. Press, Cambridge.

——. 1954. Cytological notes on one hundred species of Malayan ferns. *In* Holttum, R. E. A Revised Flora of Malaya, II. Ferns of Malaya, pp. 623-627. Gov. Print. Office, Singapore.

——. 1959. Cytological information on the ferns of west tropical Africa. *In* Alston, A. H. G., The ferns and fern-allies of west tropical Africa, pp. 75-81. Crown Agents for Oversea Gov. Administ., London.

——, J. D. Lovis, G. Vida. & M. Gibby. 1986. Cytology of the fern flora of Madeira. Bull. Br. Mus. Nat. Hist. Bot. 15: 123-161.

—— & W. A. Sledge. 1954. Observations on the cytology and taxonomy of the pteridophyte flora of Ceylon. Philos. Trans. Roy. Soc. London, B, 238: 127-185

Mehra, P. N. 1961. Chromosome numbers in Himalayan ferns. Res. Bull. (N.S.) Panjab Univ. 12: 139-164.

—— & S. C. Verma. 1960. Cytotaxonomic observations on some West Himalayan Pteridaceae. Caryologia 13: 619-650.

Mitui, K. 1968. Chromosomes and speciation in ferns. Sci. Rep. Tokyo Kyoiku Daigaku Sec. B. 13: 285-333.

Munshi, A. H. 1994. Cytotaxonomic studies on genus *Adiantum* in Kashmir Himalaya. Indian Fern J. 11: 68-72.

Pal, S. 1961. Chromosome numbers in some genera of Polypodiaceae. Sci. Culture 27: 499-501.

Panigrahi, G. & I. Manton. 1958. Cytological and Taxonomical observations on some members of the *Cyclosorus parasiticus* complex. J. Linn. Soc. London 55: 729-743.

Quansah, N. & D. S. Edwards. 1985. A natural bi-generic fern hybrid between *Christella dentata* and *Pneumatopteris afra*, from Ghana. Proc. Roy. Soc. Edinburgh sec. B. Biol. 86: 472.

Queirós, M. & I. Nogueira. 1989. Etudos cromossómicos em Pteridophyta de Portugal. Anales Jard. Bot. Madrid 46: 563-569.

Roy, R. P., B. M. B. Sinha & S.N. Pandey. 1969. Cyto-taxonomic studies in some epiphytic ferns of Parasnath hills. J. Cytol. Genet. 4: 97-104.

——, —— & A. R. Sakya. 1971. Cytology of some ferns of Kathmandu Valley. Brit. Fern Gaz. 10: 193-199.

Roy, S. K. & I. Manton. 1965. A new base number in the genus *Lygodium*. New Phytol. 64: 286-292.

Schifferdecker, I. 1957. Untersuchungen uber die Gattung *Pteris*, im besonderen die Zytologie ihrer apogamen Formen. Zeit. Induk. Abs. und Vererb. 88: 163-183.

Shinha, B. M. B., D. P. Srivastava & U. Prasad. 1986. Chromosome relationships and evolution of five species of *Adiantum*. J. Indian Bot. Soc. 65: 270-278.

Singh, V. P. & S. K. Roy. 1988. Cytology of forty four species from Sikkim, Himalaya. Indian Fern J. 5: 162-169.

Smith, A. R. 1971. Systematics of the neotropical species of *Thelypteris* section *Cyclosorus*. Univ. Calif. Publ. Bot. 59: 1-136..

—— & M. S. Foster. 1984. Chromosome numbers and ecological observations of ferns from El Tirol, Paraguay. Fern Gaz. 12: 321-329.

Stone, B. C. 1970. The Flora of Guam. A manual for the identification of the vascular plants of the island. Micronesica (Univ. of Guam) 6: 1-659.

Takamiya, M. 1996. Index to chromosomes of Japanese Pteridophyta (1910-1996). Japan Pteridol. Soc., Tokyo.

Tsai, J.-L. & W.-C. Shieh. 1983. A cytotaxonomic survey of the pteridophytes in Taiwan (1). Material collection and chromosome observation. J. Sci. Engin. 20: 137-159.

—— & ——. 1986. A cytogeographic study of the fern genus *Cyclosorus* in Taiwan. J. Sci. Engin. 23: 83-106.

Vasudeva, S. M. & S. S. Bir. 1982. Chromosome numbers and evolutionary status of ferns and fern allies of Pachmarhi Hills (Central India). Aspect of Plant Sci., 6. pp. 119-181. Today & Tomorrow's Print. & Publ., New Delhi.

Verma, S. C. & S. P. Khullar. 1965. Cytology of some W. Himalayan Adiantaceae (sensu Alston) with cytotaxonomic comments. Caryologia 18: 85-106.

Wagner, W. H. Jr. 1963. A biosystematic survey of United States ferns, preliminary abstract. Amer. Fern J. 53: 1-16.

—— & D. F. Grether. 1948. Pteridophytes of Guam. Occ. Papers Bernice P. Bishop Mus. 19: 25-99.

Walker, T. G. 1962. Cytology and evolution in the fern genus *Pteris* L. Evolution 16: 27-43.

——. 1985. Cytotaxonomic studies of the ferns of Trinidad 2. The cytology and taxonomic implications. Bull. Brit. Mus. Nat. Hist. (Bot.) 13: 149-249.

Wang, Z.-R. 1989. A preliminary study on cytology of Chinese *Pteris*. Acta Phytotax. Sin. 27: 421-438.

Weng, R.-F. 1985. Observation on chromosomes of some Chinese ferns. J. Wuhan Bot. Res. 3: 367-370.

——. 1990. Cytological observations on some Chinese ferns. Acta Phytotax. Sin. 28: 27-33.

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